

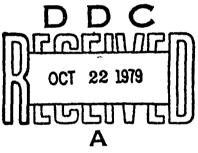
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THE SCALING OF BIRD IMPACT LOADS

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June 1979



TECHNICAL REPORT AFFDL-TR-79-3042
Final Report for Period 16 January 1978 - 16 February 1979

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This technical report has been reviewed and is approved for publication.

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FOR THE COMMANDER

AMBROSE B. NUTT

Director

Vehicle Equipment Division

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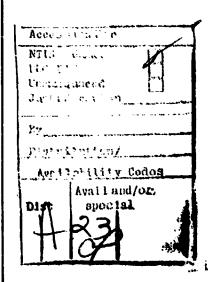
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scaled linearly with bird dimensions. The impact behavior of large birds was consistent with flow models developed to describe small bird impacts. It was concluded that large and small birds display the same fundamental impact loading processes and that these processes are adequately described by the previously developed flow model.





#### **FOREWORD**

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This report describes a contractual work effort conducted by personnel of the Impact Physics Branch, Experimental and Applied Mechanics Division, University of Dayton Research Institute, Dayton, Ohio under Project 2402, "Vehicle Equipment Technology," Task 240203, "Aerospace Vehicle Recovery and Escape Subsystems," Work Unit 24020318, "Simulation of Bird Impact on Aircraft Transparencies."

The work reported herein was performed during the period 16 January 1978 to 16 February 1979 under the direction of Dr. John P. Barber, the principal investigator. The Air Force project engineer was Mr. Robert E. McCarty (AFFDL/FER). The report was released by the authors in March 1979.

This report is one of three which will be published under contract number <u>F33615-78-C-3402</u>, The remaining two will deal with the effects of bird attitude upon impact loads, and development of a substitute bird for testing respectively and will be released as the work is completed.

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# LIST OF SYMBOLS

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Radius of projectile
Inside diameter
Mass
Outside diameter
Measured peak pressure
Hugoniot pressure
Stagnation pressure
Radial distance from center of impact
time
Impact velocity
Normal component of impact velocity
Shock velocity
Density of projectile
Density of material with zero porosity

### LIST OF UNITS

= 0.0022046 lb<sub>m</sub> (pound-mass) g (gram) Mass = 10<sup>3</sup>g kg (kilogram) = 3.2808 ft (feet) m (meter) Length = 39.37 in (inches) cm (contineter) = 0.01 m = 2.54 innm (millimeter) = 0.001 m s (second) Time us (microsecond) =  $10^{-6}$ s N (Newton) = 0.2248 lb<sub>f</sub> (pounds-force) NN (Meganewton) =  $10^6$ N Force =  $0.0624 \text{ lb}_{\text{m}}/\text{ft}^3$ =  $3.613 \times 10^{-5} \text{ lb}_{\text{m}}/\text{in}^3$  $kg/m^3$ Density  $MN/m^2$ = 10 bars Pressure =  $145.04 \text{ lb}_f/\text{in}^2$ H<sub>z</sub> (hertz) Frequency  $kH_z^a$  (kilohertz) =  $10^3 H_z$ 

# SECTION I INTRODUCTION

Collisions between birds and aircraft have proved to be an expensive and persistent problem to the United States Air Force. The severity of the problem has increased as high-speed, low-altitude aircraft missions have evolved. Windshield, canopy, and support structures have proved to be particularly vulnerable to birdstrike. Not only are these parts of the aircraft sensitive to impact damage, but the consequences of damage on pilot performance are severe. A number of aircraft and pilots have been lost due to birdstrike on windshields, canopies, and support structures.

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The birdstrike vulnerability of the crew enclosure and transparencies in Air Force aircraft has resulted in a number of redesign programs. These redesign programs have usually been conducted in an iterative build and test mode. This method of design is extremely expensive and time consuming. Force has, therefore, developed an interest in modern structural design techniques applied to the windshield birdstrike problem. This approach to the birdstrike design task involves the use of modern finite element structural analysis techniques. techniques have been adapted to analyze the transient dynamic events such as birdstrike. The structural analysis techniques themselves have undergone extensive development over the years and have become highly reliable and efficient structural design tools. In order to adequately predict response, however, these techniques require good definition of the material properties and accurate descriptions of the transient impact loads. This report deals with the description of impact loads for use with finite element codes.

The University of Dayton Research Institute (UDRI) began work on the characterization of bird impact loads in January

of 1974. This work was jointly sponsored by the Air Force Materials Laboratory (AFML) and the Air Force Flight Dynamics Laboratory (AFFDL). A continuing effort has been conducted on the measurement and characterization of bird impact loads since that time. The original work, documented in Reference 1, developed the basic experimental techniques which were used throughout the program to obtain bird impact load data. program concentrated on small birds (up to 120 g) and impacts at normal incidence. Work was continued on the measurement of small bird impact pressures. The data were more thoroughly analyzed and presented in Reference 2. This report identified the basic processes of bird impact and provided the first quantitative measurements of the pressures and forces involved. The work was extended and reported in Reference 3, which described in great detail the impact behavior of birds. Extensive data on birds weighing up to 600 g were reported. Some data for birds up to 4 kg were also obtained. The basic fluid behavior of birds during impact was identified and quantified. The development of the first satisfactory bird impact flow models was reported and the techniques necessary for proper scaling of the impact loads with bird size were identified. A more detailed theoretical base for bird impact modelling was described in Reference 4. This work presented a more detailed analysis of

<sup>&</sup>lt;sup>1</sup>Barber, J.P. and J.S. Wilbeck, "The Characterization of Bird Impacts on a Rigid Plate: Part I," AFFDL-TR-75-5, ADA021142, January 1975.

Peterson, R.L. and J.P. Barber, "Bird Impact Forces in Aircraft Windshield Design," AFFDL-TR-75-150, ADA026-628, March 1976.

<sup>&</sup>lt;sup>3</sup>Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.

<sup>&</sup>quot;Wilbeck, J.S., "Impact Behavior of Low Strength Projectiles," AFML-TR-77-134, ADA060-423, July 1978.

the basic process of bird impact and provides the theoretical basis for bird impact modelling as a fluid process. Additional impact work was conducted under an Air Force Aero Propulsion Laboratory contract and is reported in Reference 5. This report presented a much more careful experimental investigation of impact loads using simulated birds and ice. Careful measurements were made and agreement with prediction of the theoretical model was found to be excellent.

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All of the work described above was conducted with, and based on, data produced with birds weighing 600 g or less. Although scaling derived from theoretical considerations worked extremely well over the range of bird masses from 60 g to 600 g, there was still some concern about the applicability of these models to birds with masses in the range from 1800 g to 3600 g. In particular, the 1800 g birds represent the standard design case for aircraft transparencies. It was, therefore, deemed necessary to collect experimental data on 1800 g and 3600 g birds to ensure that the theoretical models developed for use with structural element codes were applicable for this size bird. This report describes the experimental measurements made on 1800 g and 3600 g birds. The scaling relationships derived in the previous programs were checked and found to adequately describe the impact of these large birds.

<sup>&</sup>lt;sup>5</sup>Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

# SECTION II EXPERIMENTAL TECHNIQUES

The experimental work described in this report was conducted at the University of Dayton Research Institute. This section contains a description of the experimental techniques used to obtain temporally resolved pressure measurements during bird impact onto a rigid plate. Descriptions of the experimental range and launch technique, target instrumentation, and data collection are given in the sections that follow.

### 2.1 LAUNCH TECHNIQUES

For experimental investigations of bird impact, a launch technique is necessary which can accelerate birds of the required mass to the required velocities. The birds must be launched with controlled orientation (preferably with zero pitch and yaw), and such that they do not break up or severely distort prior to impact. A launch technique was developed with which birds of up to 3.6 kg could be launched to velocities up to approximately 300 m/s.

The system consisted of a 177.8 mm bore compressed air gun with supporting compressor, instrumentation, and control systems. The compressor system consisted of a 1.42 m³/min, 3.5 MN/m² compressor pumping into a 0.11 m³ intermediate storage tank. The intermediate storage tank was connected via a flexible hose and quick disconnect coupler to the large air storage tank used for driving the gun. The driving air storage tank had a capacity of approximately 0.85 m³. There was a valve system located between the driving air storage tank and the breech of the gun. This valve system was designed to valve the high pressure air from the driving storage tank into the gun to

operate the gum. The valve was a standard butterfly valve system with a pneumatic actuator. The breech end of the gum, together with the compressor storage tank and driving tank systems, is shown in Figure 1.

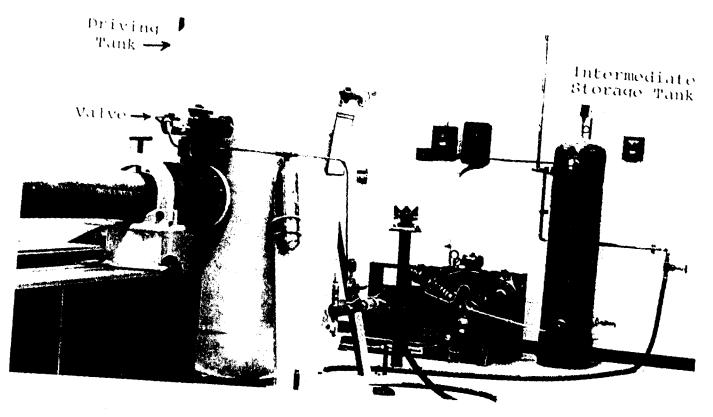


Figure 1. Compressor Storage Tank and Driving Tank Systems

The gun itself consisted of two, 4.88 m long, 177.8 mm

ID heavy wall tubes. They were connected together via a locating ring and flange system. The tubes were supported on two heavy 1-beams bolted to the floor. A vent section was connected to the muzzle of the gun tube and was designed to release the driving pressure from the back of the projectile package. This vent section was enclosed in a muffler which deflected the venting gases harmlessly towards the floor.

The birds were placed in a sabot, or carrier, for launching. The sabot was a 177.8 mm OD foam plastic cylinder. Foam plastic was employed, as a substitute of balsa wood, after identifying

several unsatisfactory characteristics of the original balsa wood sabots. There is only one supplier of balsa wood in the United States, and the sizes and quantities which could be supplied were only marginally satisfactory for these large sabots.

180 mm balsa planking was not available, so up to nine smaller planks had to be bonded together to form a work piece large enough to fabricate these sabots. This fabrication technique produced sabots which were only marginally strong enough. They often broke during fabrication. The molded plastic sabots proved completely satisfactory for launching birds over the range of sizes and velocities used in this study. They are light, strong and very dimensionally stable.

As the sabot represents a significant fraction of the launch mass, it must be stripped from the bird before the bird impacts the target. Accordingly, a tapered tube sabot stripping section was connected to the muzzle end of the vent section. The sabot stripper tube consisted of a steel tube with an initial ID of 177.8 mm that was progressively reduced. A series of longitudinal wide slots were cut into the stripper tube to facilitate the rapid release of the driving pressure, thus reducing the forces required to decelerate and stop the sabot. When the launch package entered the sabot stripper tube, the sabot was progressively decelerated until it stopped. The bird released from the sabot pocket and continued on trajectory to the target. For the high velocity shots, an extension to the stripper tube was required. It consisted of nine bars welded around a ring and connected to the stripper tube through a flange system. The vent section muffler and stripper tube are shown in Figure 2. The sabot stripper functioned satisfactorily over the entire range of masses and velocities which were used in this program.

Free flight observations of the bird showed that the bird was oscillating after sabot separation. This oscillation was apparently initiated by the release of the bird from the sabot. To assist in the smooth release of the bird, holes were drilled in the base of the sabot. These holes permit the driving pressure

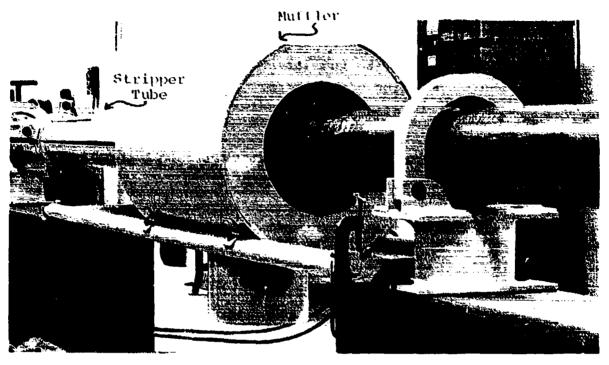


Figure 2. The Vent Section Muffler and Stripper Tube

to act on the base of the bird itself. Therefore, the bird was both pushed and pulled out of the sabot during the separation process. This technique appeared to greatly reduce the bird oscillation problem.

# 2.2 VELOCITY, LOCATION, AND ORIENTATION MEASUREMENT

The velocity of the bird was measured prior to impact using a simple time of flight technique. Between the muzzle of the sabot stripper and the target, two helium/neon laser beams were directed across the trajectory. When the bird interrupted the first laser beam, a counter was started. The counter was stopped when the bird interrupted the second laser beam. The distance between the laser beams and the elapsed time were used to calculate the velocity. To increase the accuracy of the velocity measurements, monitor bird orientation, determine projectile impact location on target, and verify bird integrity

prior to impact, two orthogonal pulsed x-ray systems were set up at each laser beam station. The resulting radiographs of the bird in flight were used to accurately establish the position of the bird with respect to the laser beam and to monitor the condition and orientation of the bird. The accurate determination of projectile location and orientation relative to the target is necessary to properly describe the pressure distribution. Using this technique, velocities could be measured to within one percent, projectile impact location on target could be determined to within about 1.25 cm, and orientation to within !0.5 degrees. Bird disintegration during launch was extremely rare and was not an experimental problem. The instrumentation described above is shown in Figure 3.

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### 2.3 PRESSURE MEASUREMENTS AND RECORDING

The impact shock pressures can be extremely high, the duration of the impact is relatively short and there could be important transient pressure excursions. The pressure sensing devices must be capable of measuring and withstanding these high pressures and the pressure sensing and recording equipment must have adequate bandwidth to detect and record important pressure transients.

Piezoelectric quartz pressure transducers were used as the basic sensing devices for these experiments. These transducers have a compact impedence converter physically located in the coaxial line close to the crystal, and they have a specified bendwidth from 0 to 80 kHz. Since these transducers are not specifically designed for impact testing, calibration was necessary to verify their operation. In Reference I Barber gives details of calibration techniques in his report. The

Barber, J.P. and J.S. Wilbeck, "The Characterization of Bird Impacts on a Rigid Plate: Part 1," AFFDL-TR-75-5, ADA021142, January 1975.

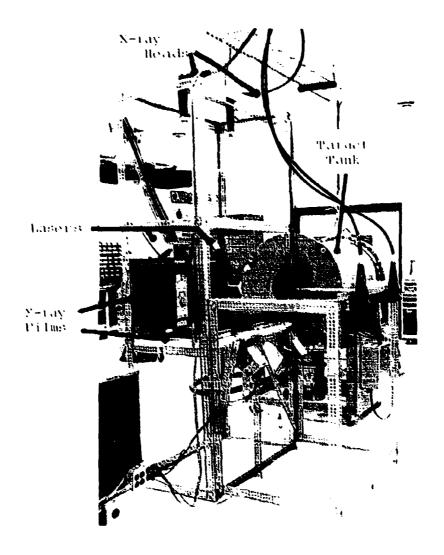


Figure 3. Instrumentation Section

transducers were mounted flush with the surface of a heavy steel plate. Up to nine transducers were simultaneously mounted in the plate on orthogonal axes.

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The pressure signals were recorded using an electronic digital memory system. This system uses an analog to digital signal converter. The system has a 200 kHz sample rate, and each channel can store 2048 data points in shift registers. The pressure signals were displayed on an oscilloscope, as a function

of time, and the time interval of interest determined. Then, digital data over these intervals was recorded on a cassette and could be printed out on an electronic data terminal. This technique significantly increased the accuracy and reliability of the data.

# SECTION 111 EXPERIMENTAL RESULTS

A total of 83 data shots were performed to investigate the scaling of bird impact loads. The objective was to demonstrate that the scaling relationships which worked extremely well over the range of bird masses from 60 to 600 q, were applicable to bird masses ranging from 1800 to 3600 q. The projectiles used in these tests included birds (chickens) and bird substitutes (porous gelatin). They were impacted at three impact angles (90°, 45°, 25°) and at velocities ranging from 100 m/s to 300 m/s. The substitute birds were right circular cylinders with a length to diameter ratio of approximately two.

The time varying pressure data were collected using a digital data memory system as described in Section II. From these recorded data, measurements were made to obtain peak pressure and steady flow pressure. The results of these measurements together with comparisons to theoretical results and measurements from impacts of smaller size birds and bird substitutes reported by Barber in Reference 3 and Bauer in Reference 5 are presented in the following sections.

### 3.1 INTRODUCTION

Birds independent of their masses can be assumed to be right circular cylinders with a length to diameter ratio greater

Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.

Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

than two, and to behave like fluids during impacts. These two basic assumptions provide the basis for understanding the scaling of bird impact loads.

Because the impact process is basically fluid dynamic, the characteristic pressures are the Hugoniot, or impact, pressure and the flow, or stagnation, pressure. Both of these pressures depend only on the impact velocity and the material properties of the bird (i.e., density and shock velocity). The magnitudes of these pressures should not vary with bird size, however, the spacial and temporal distribution of pressure should. Since birds of different mass are, however, deometrically similar (i.e., they have similar length to diameter ratios), pressure distributions should scale linearly with bird dimensions. That is, pressure distributions should depend only on normalized distances (where normalization is carried out with a bird dimension such as diameter or length). This was, in fact, shown in Reference 3 for birds and Reference 5 for substitute birds up to 600 q.

Bird and gelatin impacts on a steel target plate may be considered as soft body impacts since the stresses generated during impact substantially exceed the strength of the projectile but are well below the strength of the target material. Pressure records obtained from such impacts are shown in Figure 4, 5 and 6. Figures 4 and 5 show typical pressure traces from normal and oblique impact of a nominal 1800 q and 3600 q right circular cylindrical gelatin projectile. Figure 6 shows similar pressure traces from impacts of a real bird (chicken). The two pressure

Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.

Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

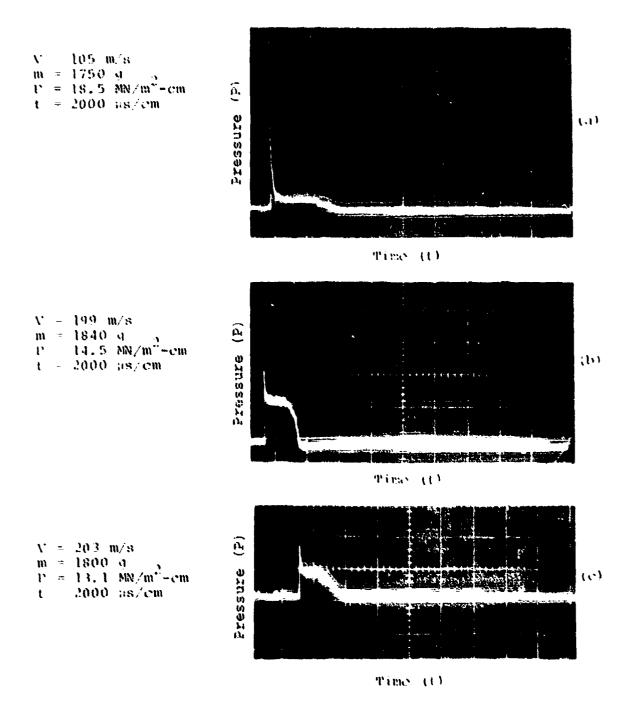


Figure 4. Typical Pressure-Time Record of Nominal 1800 a Gelatin with 10% Porosity. (a) 90% impact, center transducer; (b) 45% impact, 3% below center; (c) 25% impact, center transducer.

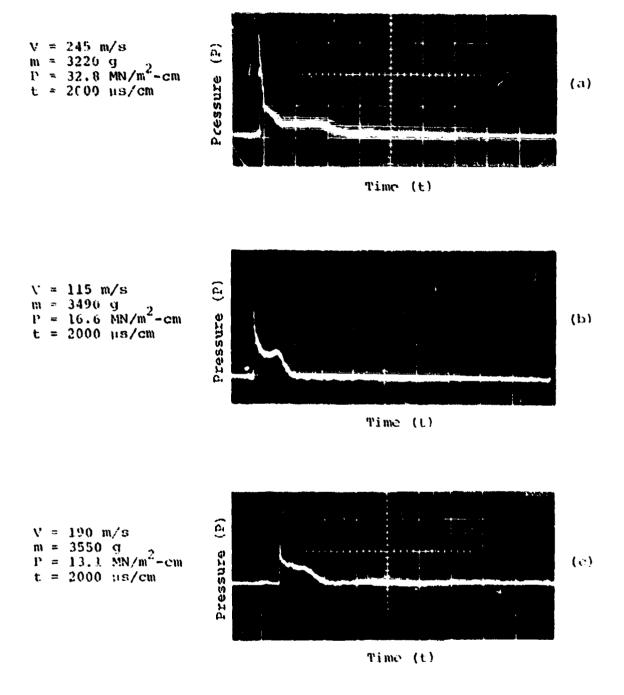


Figure 5. Typical Pressure-Time Record of Nominal 3600 a Gelatin with 10% Porosity. (a) 90% impact, 1% above center; (b) 45% impact, center transducer; (c) 25% impact, center transducer.

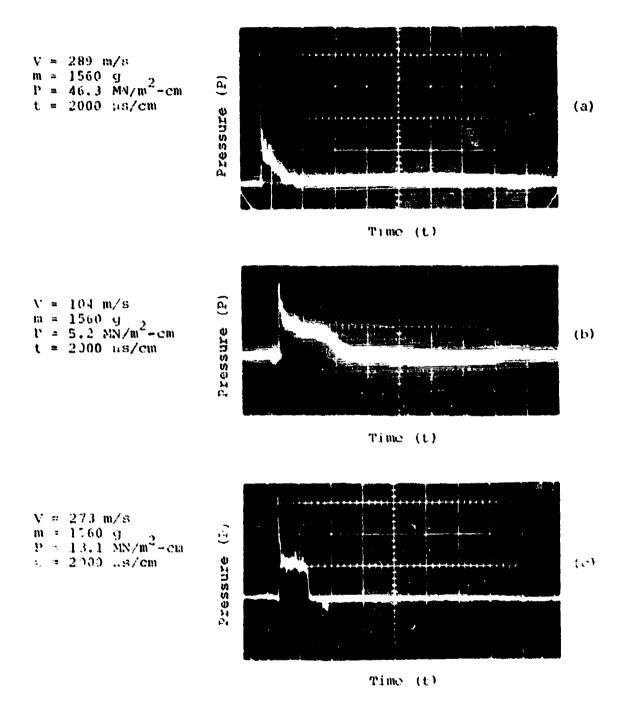


Figure 6. Typical Pressure-Time Record of Nominal 1800 g Real Bird (chicken). (a) 90° impact, center transducer; (b) 45° impact, center transducer; (c) 25° impact, center transducer.

levels of interest on these traces are the peak pressure and the steady flow pressure.

The peak pressure is due to a shock wave formed from the initial impact, and is mainly a function of the normal component of impact velocity and the projectile's properties. The steady flow pressure occurs when the initial shock wave is overtaken by the release waves formed from the pressure gradient along the projectile's edge. The phases of the impact process are shown in Figure 7.

#### 3.2 IMPACT DURATION

The time duration of impact of birds was first derived by Barber in Reference 3 and was found to equal the projectile length divided by the impact velocity. The same results were found during this experimental program. These results also agree with the results presented by Bauer in Reference 5 during his experimental investigation on simulated birds.

#### 3.3 INITIAL IMPACT PRESSURE

During the initial impact, the particles on the front surface of the projectile are instantaneously brought to rest relative to the target face and a shock propagates into the projectile. As the shock wave propagates into the projectile, it brings the material behind the shock to rest. The pressure in the shock compressed region is initially very high and is uniform across the impact area. The pressure behind the shock,

Barber, J.P. and H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.

<sup>&</sup>lt;sup>5</sup>Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

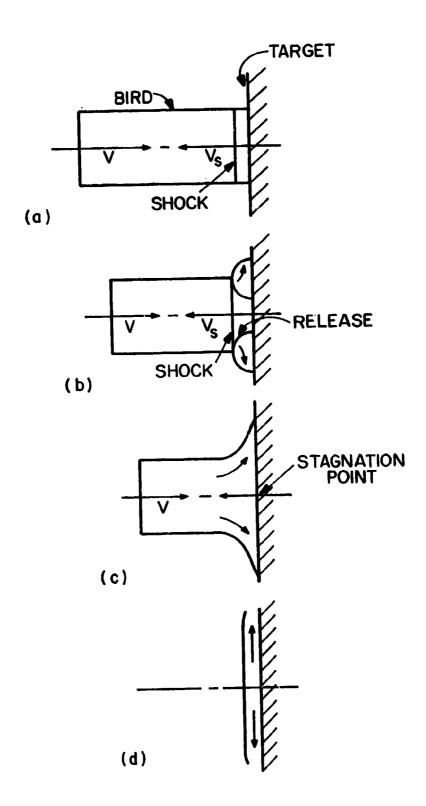


Figure 7. The Phases of Bird Impact: (a) Initial Impact, (b) Impact Decay; (c) Steady Flow; and (d) Termination

(the Hugoniot pressure) is:

$$P_{H} = \rho V_{S} V_{n} \tag{1}$$

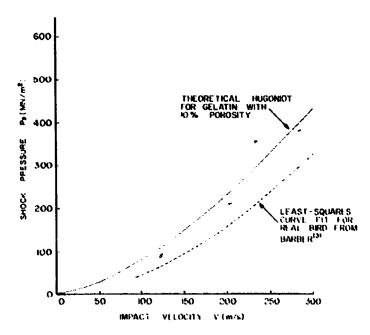
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where p is the density of the rojectile,  $V_{g}$  is the shock velocity, and  $V_n$  is the normal component of impact velocity. relation between the shock velocity  $V_{_{\mathbf{S}}}$  and the normal component of impact velocity  $V_{\mathbf{n}}$  for gelatin with 10 percent porosity was derived by Wilbeck in Reference 4. The initial impact pressures measured for all normal and oblique impacts for bird and gelatin are presented in Figures 8, 9, and 10. The measured impact pressures for normal impact for nominal 1800 g real bird agree very well with the calculated pressures. The agreement is better than the experimental results from small birds reported by Barber in Reference 3. The small bird data were probably affected by the limited bandwidth (80 kHz) of the transducers. The shock pulse was barely defined for the large birds (see Figures 4-6). Shock pulse duration was only about half as long for the small bird impacts, and the peaks may have been clipped. The measured shock pressures for normal impact for gelatin with 10 percent perosity are well above those anticipated. The shock pressures approached those expected for pure golatin and were up to twice as high as those expected for the porous delatin bird simulant material. A thorough investigation was conducted and the source of these extremely high and unexpected pressures was determined and eliminated during the later shots.

It was found that the part of the bird initially striking the target was essentially pure gelatin. Birds were launched

<sup>&</sup>quot;Wilbeck, J.S., "Impact Behavior of Low Strength Projectiles," AFML-TR-77-134, ADA060-423, July 1978.

Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.



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Figure 8a. Initial Impact (Hugoniot) Pressures versus Impact Velocity for Nominal 1800 g Real Bird (chicken) at Normal Impact

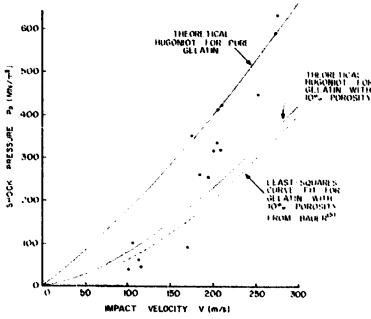


Figure 8b. Initial Impact (Hugoniot) Pressure versus Impact Velocity for Nominal 1800 g and 3600 g Gelatin at Normal Impact. Points show data from this program.

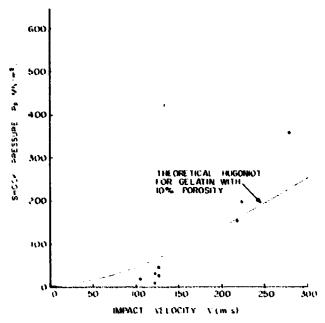


Figure 9a. Initial Impact (Hugoniot) Pressures Versus Impact Velocity for Nominal 1800 g Real Bird (chicken) at 45° 1mpact

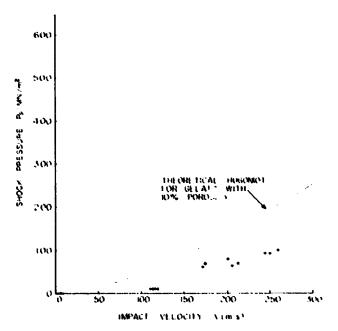
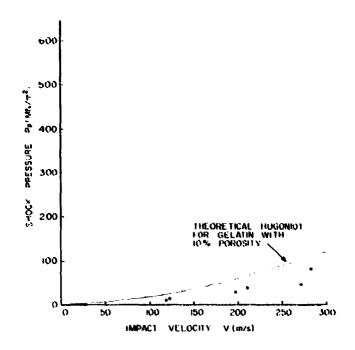


Figure 9b. Initial Impact (Hugoniot) Pressures Versus Impact Velocity for Nominal 1800 g and 3600 g Gelatin with 10 Percent Porosity at 45° Impact



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Figure 10a. Initial Impact (Hugoniot) Pressures versus Impact Velocity for Nominal 1800 g Real Bird (chicken) at 25° Impact

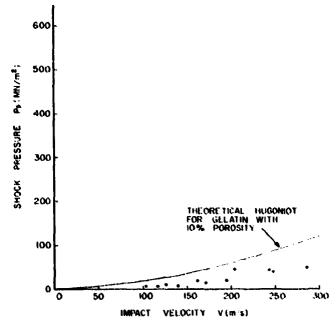


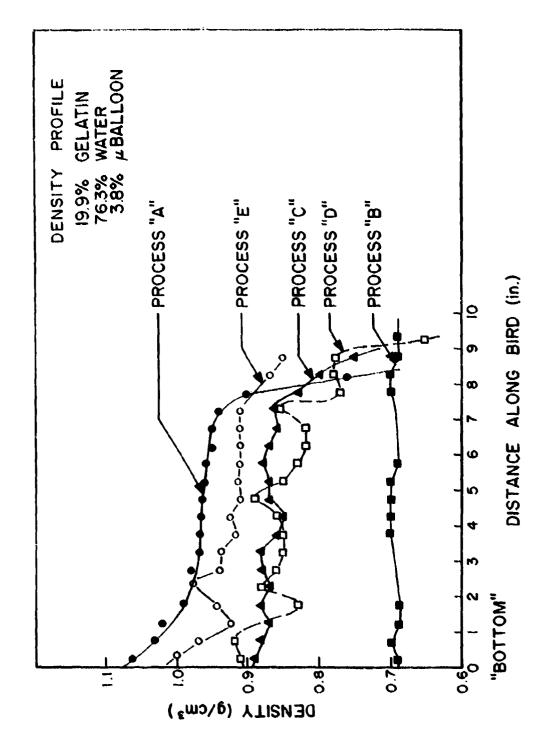
Figure 10b. Initial Impact (Hugoniot) Pressures versus Impact Velocity for Nominal 1800 g and 3600 g Gelatin at 25° Impact.

such that the end of the bird which first struck the target was the end that was at the bottom of the mold during the molding process. The presence of pure gelatin at the bottom of the mold was due to the tendency of the phenolic microballoons, which were used to provide porosity, to float out of the gelatin during the curing process. This was confirmed by making density measurements along the axis of the bird. The results for several processes are shown in Figure 11. Pure gelatin was found at the bottom of the mold and extremely low density gelatin at the top of the mold. Numerous different processing techniques were tried in an attem t to eliminate the density gradients from the bird. As can be seen from Figure 11, good density uniformity was obtained in many cases but in general the density was too low. Efforts to increase density always resulted in increased density gradients. As a result of this investigation, birds were molded some 30 percent longer than the nominal bird length and approximately 15 percent was trimmed from each end. This technique produced density variations which fell between acceptable limits. To further insure that the very high peak pressures were not produced, birds were launched top end (low density end) first. These changes produced better behavior in the later oblique shots. The measured impact pressures for oblique impact for gelatin and real birds are, as expected, lower than the calculated values. In addition, low recorded peak pressure during oblique impacts may have also been caused by the relatively shorter duration of the shock pulse in these impacts. As pointed out earlier, the limited bandwidth of the transducers can result in a significant attenuation of the measured signals. For 25° and 45° impacts, the initial impact pressure spike was much less pronounced than for 90° impacts.

### 3.4 STEADY FLOW PRESSURES

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As the shock wave propagates into the projectile, the material at the edge of the projectile is subjected to a very high pressure gradient. This pressure gradient causes the



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Density Profiles for 415 Simulant Birds Prepared with Different Techniques Figure 11.

material to be accelerated radially outward, and release waves propagate inward. The function of these release waves is to relieve the radial pressure gradient in the projectile. Release waves travel into the projectile, eventually evertaking the initial shock wave. The release process for a cylinder is shown in Figure 12. As the radial pressure decreases during the shock pressure decay, shear stresses develop in the projectile material. These shear stresses are greater than the shear strength of the material and are sufficient to cause "flow". Then, the bird can be considered to behave as a fluid. After several reflections of the release waves, a condition of steady flow is established. A constant pressure and velocity field is set up in the projectile and remains until the end of the projectile reaches the target surface. This steady-state phase is usually indicated by a pressure plateau on the pressure traces. could be seen in Figures 4, 5, and 6, a large amount of high frequency "noise" was superimposed on the pressure profiles, which made it hard to identify the plateau and to make an accurate measurement of steady-state pressure. Therefore, an average value of the pressure was measured and used in presenting the pressure distributions. This noise was investigated in Refevence 4 by Wilbeck and might have been caused by the breakup or tearing of the material (creation of new surfaces) during impact or by the acceleration loads on the gages caused by the pressure plate vibrations.

Using potential flow theory, Wilbeck calculated, in Reference 4, the steady-state pressure for a bird impact at normal incidence. The pressure at the center of impact was found to equal the stagnation pressure which was approximated by:

$$P_{s} \sim \frac{1}{2} \rho_{o} v^{2} \tag{2}$$

<sup>&</sup>quot;Wilbeck, J.S., "Impact Behavior of Low Strength Projectiles," AFML-TR-77-134, ADA060-423, July 1978.

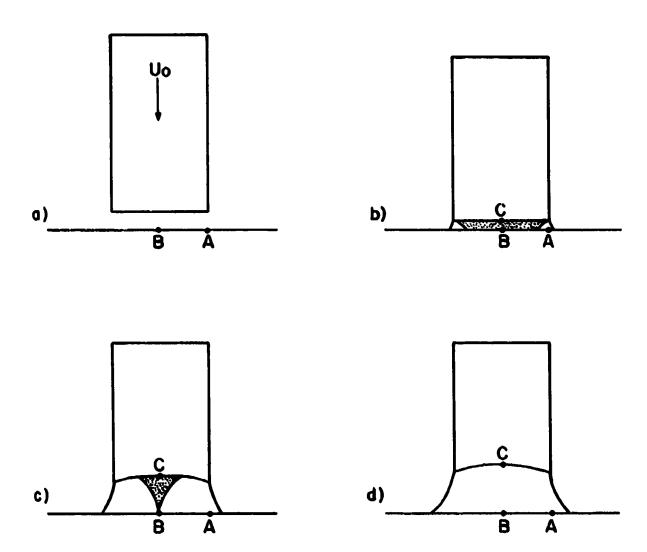


Figure 12. Shock and Release Waves in Fluid Impact. (a) before impact; (b) shocked region just after impact; (c) release waves have converged on Point B, the axis of the cylinder; (d) release waves have just caught the center of the shock, Pt. C.

where  $\rho_{\rm O}$  is the density of the material with zero porosity and v is the impact velocity. The stagnation pressure is the highest pressure during the steady flow regime and is an important factor in scaling bird impact loads, since it is used to nondimensionalize the steady flow pressure distribution.

For oblique impact, the majority of fluid will flow "down-stream" on the obtuse side of the impact. The stagnation point shifts "upstream" to the acute side of the center of impact as shown in Figure 13. As long as a stagnation point exists, the

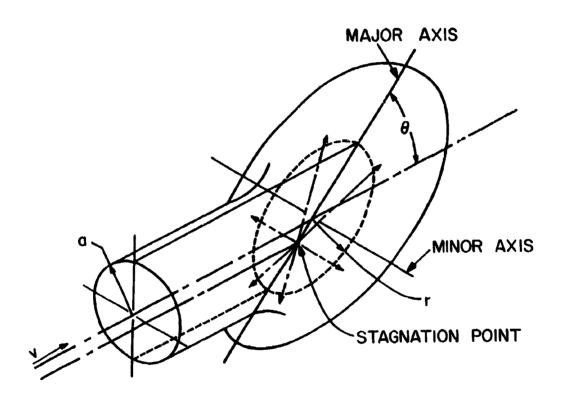


Figure 13. Flow Geometry at Oblique Impact

full stagnation pressure will occur at the stagnation point regardless of angle of impact. However, the distribution of pressure along the surface will be greatly dependent on the impact angle. The distribution of pressure in an oblique cylindrical impact is difficult to analyse because it is a

three-dimensional fluid dynamic problem. In Reference 6, Boehman used potential flow theory to develop a computer model for predicting the pressure distribution produced by the steady state flow of a cylindrical jet impacting on a rigid flat plate. The code utilizes a source density distribution on the surface of the plate and solves for the pressure distribution necessary to make the normal velocity zero on the boundary. Originally, the input to this program consisted of the coordinates of points describing the body surface. For our purposes, the code was modified to generate a grid describing the plate, where the size of the grid depends on the mass of the bird and the angle of impact. A listing of the modified code along with a sample input and output data is presented in the Appendix. The experimental pressure data measured in this task is compared to those theoretical curves and to the experimental data from Reference 3 by Barber and Reference 5 by Bauer in the following sections.

### 3.4.1 Gelatin Artificial Birds

Figures 14, 15, and 16 show the nondimensionalized steady flow pressure distributions along the major axis produced by gelatin with 10 percent porosity for 90°, 45°, and 25° impact angles, respectively. The pressures are normalized to the stagnation pressure as calculated in Equation (2). Together with the experimental data, two sets of curves are shown in these figures. The predicted pressure distribution from

<sup>&</sup>quot;Boehman, L.I., and A. Challita, "A Model for Predicting Bird and Ice Impact Loads on Structures," IDR-TR-79-54.

<sup>&</sup>lt;sup>3</sup>Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADAO61-313, May 1978.

<sup>&</sup>lt;sup>5</sup>Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

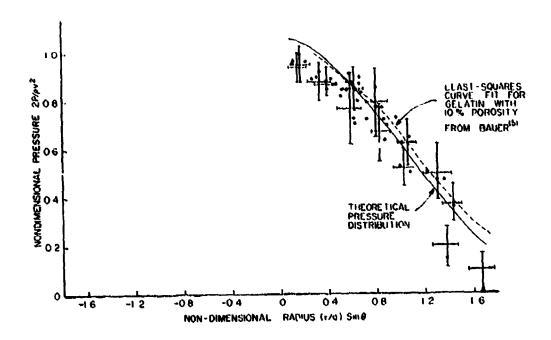


Figure 14. Normalized Steady Flow Pressure Distribution of Nominal 1800 g and 3600 g Gelatin with 10% Porosity Along Major Axis at Normal Impact

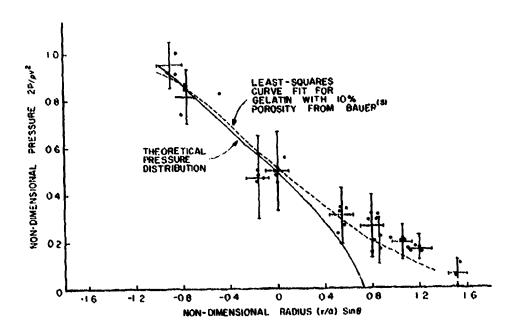


Figure 15. Normalized Steady Flow Pressure Distribution of Nominal 1800 g and 3600 g Gelatin with 10% Porosity Along Major Axis at 45° Impact

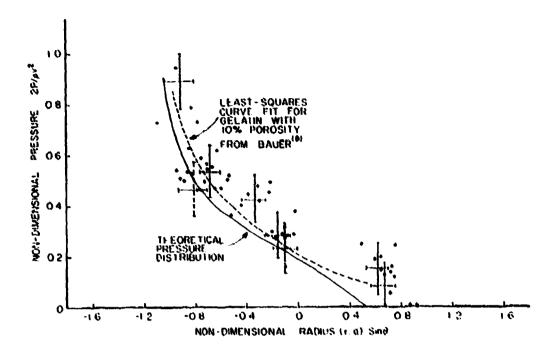


Figure 16. Normalized Steady Flow Pressure Distribution of Nominal 1800 q and 3600 g Gelatin with 10% Porosity Along Major Axis at 25° Impact

Reference 6 by Boehman for normal (90°), 45°, and 25° impacts, and the least-squares curve—fits of the experimental data for smaller size gelatin projectiles from Reference 5 by Bauer. The error bars shown parallel to the ordinate axis represent the uncertainty in measuring the steady state pressure from the pressure traces created by the superposition of the high frequency noise on the pressure profile of birds. The error bars shown parallel to the abscissa are based on the maximum error in determining the initial impact location on the target. The maximum error was calculated in Reference 5 by Bauer and is

<sup>\*</sup>Boehman, L.I. and A. Challita, "A Model for Predicting Bird and Ice Impact Loads on Structures," UDR-TR-79-54.

Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

caused by the displacement of the actual trajectory from the true trajectory of the projectile.

This set of figures shows the important effect that impact angle has on steady flow distribution. As the impact angle changes from normal to oblique, the steady flow pressure distribution changes from symmetrical about the center of impact to highly skewed about the stagnation point. It also shows that the location of the stagnation point in the flow field moves from the center of impact to a point actually outside the projected frontal area of the incoming projectile. The figures show that projectile size has no effect on steady flow pressures. The data for both 1800 g and 3600 g gelatin projectiles are included in the figures and, in nondimensionalized (scaled) form, show no significant departure from the smaller bird results.

Agreement among the theoretical curve, curve fit of the experimental data for smaller size gelatin projectiles, and the experimental data from this work is very good at all angles of impact. Some disagreement between the data and the flow model predictions does occur near the outside edge of the flow, because the analytically predicted pressure distribution was generated from a simplified model of onset flow.

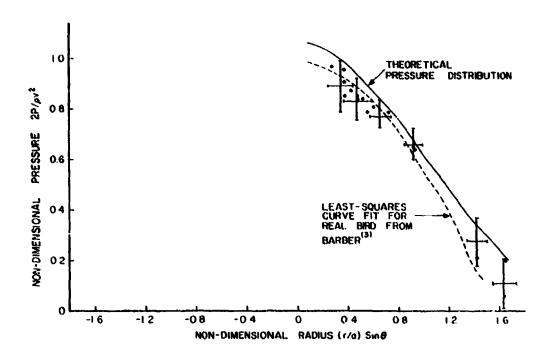
#### 3.4.2 Real Birds

Figures 17, 18, and 19 show the steady flow pressure distributions along the major axis for real bird impacts.

Again, the theory and the least-squares curve fit of the experimental data for smaller size birds from Reference 3 by Barber are shown on these figures. Error bars similar to that shown for gelatin are also shown.

All of the characteristics of steady flow apparent in the gelatin impacts are also apparent for real birds. The

Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.



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Figure 17. Normalized Steady Flow Pressure Distribution of Nominal 1800 g Real Bird (chicken) Along Major Axis at Normal Impact

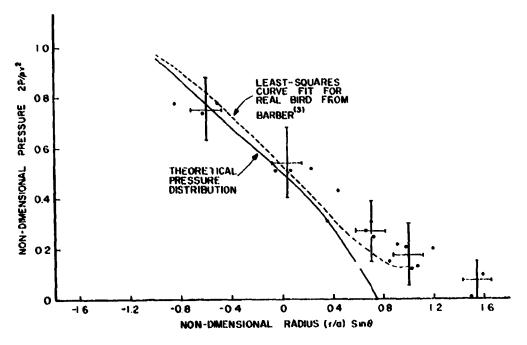


Figure 18. Normalized Steady Flow Pressure Distribution of Nominal 1800 g Real Bird (chicken) Along Major Axis at 45° Impact

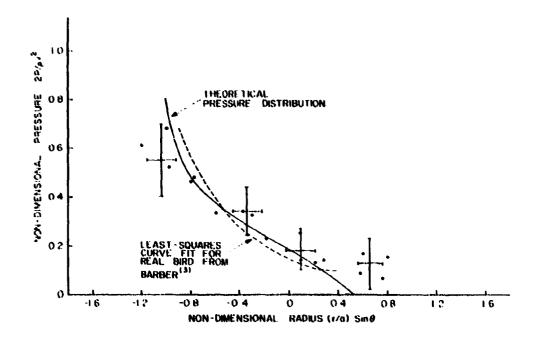


Figure 19. Normalized Steady Flow Pressure Distribution of Nominal 1800 g Real Bird (chicken) Along Major Axis at 25° Impact

stagnation point moves from the center of impact to a point outside the projected frontal area of the incoming projectile and the steady flow pressure distribution is highly dependent on the impact angle. There is good agreement among the theoretical curve, curve fit of the experimental data for smaller size birds, and the experimental data from this program.

This data also demonstrates that for the 1800 q projectiles, there are no significant differences between loads produced by real and gelatin birds. In Reference 5 Bauer found a similar result for 90 q and 600 q projectiles.

Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Lee," UDR-TR-78-114, November 1978.

# SECTION IV CONCLUSIONS AND DISCUSSION

A detailed body of impact pressure data now exists for real birds (chickens) and bird substitutes (gelatin with 10 percent porosity) over an enormous range of impact parameters. The parameters and their ranges are:

- 1) Bird mass 60 g to 3600 g
- 2) Impact velocity 50 m/s to 300 m/s
- 3) Impact angle 25° to 90°

This entire body of data has been successfully analysed and the important impact processes identified, functional relationships between the impact pressures and impact parameters developed and scaling of impact loads with bird mass completed. From the work reported here and in Reference 3 by Barber, Reference 2 by Peterson and Barber, Reference 4 by Wilbeck, and Reference 5 by Bauer, the following conclusions may be drawn.

1) Birds behave as a fluid during impact at the impact velocities of interest in birdstrike (>50 m/s).

<sup>&</sup>lt;sup>3</sup>Barber, J.P., H.R. Taylor, and J.S. Wilbeck, "Bird Impact Forces and Pressures on Rigid and Compliant Targets," AFFDL-TR-77-60, ADA061-313, May 1978.

<sup>&</sup>lt;sup>2</sup>Peterson, R.L. and J.P. Barber, "Bird Impact Forces in Aircraft Windshield Design," AFFDL-TR-75-150, ADA026-628, March 1976.

Wilbeck, J.S., "Impact Behavior of Low Strength Projectiles," AFML-TR-77-134, ADA060-423, July 1978.

<sup>&</sup>lt;sup>5</sup>Bauer, D.P. and J.P. Barber, "Experimental Investigation of Impact Pressures Caused by Gelatin Simulated Birds and Ice," UDR-TR-78-114, November 1978.

2) There are four phases of fluid behavior during a bird impact; the shock phase of initial impact, shock pressure decay, steady flow, and termination.

- 3) Peak shock pressures are independent of bird mass but depend in a predictable manner on impact velocity, impact angle, and bird material properties.
- 4) Steady flow pressures are independent of bird mass but depend in a predictable way on impact velocity, impact angle, and bird material properties.
- 5) The spacial distribution of bird impact pressures scale linearly with bird dimensions (providing bird orientation at impact is fixed). This scaling has been tested over a range of bird mass from 60 g to 3600 g.
- 6) Impact duration is given by simply the length of the bird divided by the impact velocity. The validity of this relation has been tested for bird masses from 60 to 3600 g and for impact velocities from 50 m/s to 300 m/s.
- 7) Simulated birds effectively reproduce the pressure distribution of real birds.

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# APPENDIX BIRD LOADING MODEL

This appendix provides a listing of the modified bird loading model, a sample input and output data, and the instructions needed to run the program.

The original loading model was designed to predict impact loads and to be interfaced with finite element structural analysis computer programs, and also was designed to handle impacts on arbitrary curved surfaces. The three-dimensional potential flow theory was used to model the impact process and the surface singularity method was used to solve the complex potential flows (i.e., velocity and pressure fields). To allow arbitrary bodies to be considered, it was required that the body surface be specified by a set of points in space called nodal points and that the coordinates of all nodal points on the impacted surface be supplied to the loading model.

Input to the loading model consisted of the coordinates of the set of finite element nodal points defining the surface of the impacted object. These coordinates were given in the reference coordinate system, that is, the coordinate system used to describe the shape of the impacted surface before impact occurs.

Because the target used in this experimental program is a rigid flat plate, the loading model was modified to generate a rectangular grid describing the plate. The dimensions of the grid are proportional to the weight of the bird and to the angle of impact. The number of elements forming the grid is found by multiplying NC by NS, where NC and NS are the number of nodes along the width and length of the grid.

The input data needed for this modified version of the loading model are time, TIM, which is assumed to equal zero;

components of the velocity vector of the projectile, VBX, VBY, and VBZ; coordinates of the center of impact, XI, YI, and ZI; angle of impact, THETA; and the weight of the projectile, WB. The bird length is assumed to be twice its diameter.

The output data are divided in two parts; the first part lists the coordinates of the four corner points forming the element, the components of the unit normal vector, and the coordinates of the null point in the reference coordinate system. The main purpose of this output is to enable errors in the input to be discovered before the lengthy flow calculations are performed. The second part contains the velocities and pressures on the body surface.

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                                    PTTP-Y(3+,1)-Y(2+,D
                                    (L+E)Y (L+F)Y=EAL1
433,0000
                                    File Yels Doy(4, D
4 44,0000
435,0000
                                    111299010 (21-214424) 121442)
                                    n 15 SORO (4.32442)(132**2)
435.0000
437,0000
                                    039 8000 (4.43** 4) 143**2)
                                    031500R1 C4 14449H F14442)
430,0000
 139,0000
                                    RESORT COYOU XC1+,DOX**2+CYPP YC1+,DOX**2+ZNP**2)
                                    ROSSORI COMP. YOUR DONASTI CYMP. YOUR DONASTI ZMPAROS
440.0000
441.0000
                                    Kamilian Canic actemptate than a creative to taking the way
                                    REAL SORT COXID-XC4+(J) 1**21CYNJ-YC4+ 1134*212NP$#23
44.5.0000
443.0000
                                    としています けんとのいって(しゃけ) 水火ご
444.0000
                                    1 ()・ / N1) 本木 / F ( X M1) - X ( () + 1) ) 本水 ()
445.0000
                                    FREQUENCY PROPERTY APPROVED
                                    TALINER STATEMENT OF THE PROPERTY OF THE PROPE
446.0000
447,0000
                                    HI=(TNI* Y(1+.I))*(YNI*-X(1+,I))
                                    TO CYMP Y CZ+,DDYCXNP+X(Z+,D)
448.0000
                                    HR-(YMF-YC3+,1))*CXNI--X(3+,1))
 449,0000
 450.0000
                                    H4=(YNI'-Y(4+,1))#(XNI'-X(4+,1))
```

```
411.0000
                111450F0GCCR14R261CP374R14R240F255M14217042
                1122 番 (in a cle 2483 ) P 552 (R 248 (242 (5 ) ) 13 (3 ) 2 (3 )
2127,0000
                H23 (A) One Classical in $437 CR $4 Reg ( 0345 $40) 4.5 / 0.34
457,0000
4.4.0000
                1149 (ALTIBECTEATED THAT) (Clearlet (1141) 3341 114/1141
4114.0000
                311 HOLDS PRINTERS
                V11 -6F06C(R14R2 01237/CR14R24013334C 7E21/012)
456,0000
                USS ALTHOCOGERGE HEAVIOR (BRIGHT COSE) PLANZING O
414,0000
458,0000
                V35561 060 CR34R4-0 540 / CR34R44 (0 545 ) # (- 11 43/1034)
459.0000
                UAA AFAGCERARE 1141 VZCR44RT11141 VXC 2614/8413
                YOU VILLIOUS OR REPAR
450.0000
                (C##CO + 15Y-C + 45YY-15PPC (D+15Y + O +75) & 5 18G- 16HH
461,0000
                11fam sopreces(4), D+Xen, D) +Xn+eYe4, D+Ye2+, D) +Xn)
447,0000
45 1,0000
                HOUSE AND MAIN MAIN MAY
444,0000
                1001-2001/2507
4554,0000
                TEGORICANO DEL ARSONATO BULLO 40
48640000
                 HOR GLOBERT AND ARREST
467,0000
                11 CL . NL . 11 78140.
                BD TD 30
444,0000
459,0000 40
                HICZER (FO. 0.)
                                    W11=0.
                D CTOL FOLOD
470,0000
                                      60 10 42
                MID 1779177F21
1"1.0000
\Delta Z \geq \epsilon \alpha \alpha \alpha \alpha
                WITE ATANCE CHICKLIF HID & CONCRETE SHADOC (MICKLOFIC) & (ZNCKR2))
                H (21 32 410, 0.)
                                     M22:0.
a 13,0000 42
                TECTES LEG. O.
                                      GO TO 44
4 '4,0000
                M24-113222F32
4.%,0000
4 %,0000
                WYTE ATANCE (MC3#EC-1120 + CZNIT#R2OO - ATANCE (MC3#E3-1130 + CZNIF#R3O)
42.5.0000
                                    MA3:0.
                TECTERS JED, OU
                                      60 10 46
474,0000
                 H (2143 AR. 00)
                MA4=1 143771145
479,0000
                W43-616N0CCM34#E3-1150+CZND#R300-616N0CCM34#E4-H40+CZND#R400
400.0000
ant,0000 45
                 1E (71.14 /1.0 cm)
                                      W41=0.
487,0000
                 H C71 14 .1 R. 0.3
                                      60 10 35
                M41- FT14/7F14
483,0000
484.0000
                W44=A1ANCCCM41#E4-H4)+(/NP*R4))-ATANCCCM41#E4-H1)+(ZNP*R1))
4851.0000 AS
                1074-171-1-118XIII + 1 (2-1- 1) **YV1+T(3-1-,1) **ZW1
486,0000 30
487,0000
                UPY TELEPHONENHIATERS IN DRIVING CHARLEST
                MPZ-1CF+3+ FYXRFF1CP+3+.DXYVFF1C3+3+.DXZNF
31:81.0000
1110,0000
                VYOLUS UPX
                ひとくし・17=66人
490.0000
                りさくしゃ わっぱいき
491,0000
                AMOTA DETOSATATAMINATOSAZATAMONYETOSASATAMINZ
127,0000
493.0000
                 # C40N+15 FR. 05 BU 10 109
444.0000
495,0000
                CED XIII - IABOT - YIMEV
                CONFACTOR BY (1)
446.0000
447.0000
                UINE ALTERNATION
499.0000
                (n)(1)= (1(5-1-1)#VTNFX+T(3-2-1)#VTNFY+T(3-3-1)#VINFZ)
499,0000
                60 10 15
            109 DN([)=0.
500.0000
```

```
501.0000 15
               CONTINUE
502,0000
               CALL SETTIFF (ANIONISIN)
503.0000
               MRTHE (11.92)
504.0000
               FURMAT (2X+*1*+7X+*XPNP*+YX+*V(L*+10X+*U1*+YX+*UNX*)
505.0000 --
               WRITE (11.93)
5-56+0000
               FURNAT (10x+*YINP*+8X+**QUFL*+9X+*V1*+9X+*UNY*)
507,0000
               WRITE (11-94)
508,0000
               FURMAT (10Y-*7FNP*-10X-*CP*-10Y-*W1*-9X-*UNZ*/)
509,0000
                In: 101 1=1.N
510,0000
               111=0.
511,0000
               U1=().
512.0000
               W1=0.
513.0000
               100 102 J=1+N
514,0000
                T1=UX(T,.1)#$(,1)
515.0000
                (U) 2*(U, I) YU="T
516.0009
                (L)2*(L+1)\V=6T
517,0000
               111=U1+T1
518,0000
                V1=V1+T2
519.0000
               41=W1+13
520,0000
               CONTINUE
521,0000
                TE (NK(I) .FR. 0.) GD TG 310
522,0000
                U1=DT+COSAL-UX(T)
523,0000
                CT)YU~38207410±10
524,0000
                MI=WELCOSGA-UZ(I)
525.0000
          310
               THAT INH!
ካድል , ዕዕዕፅ
                VEL=SURT (101**24V1**24W1**2)
527.0000
                SOULT = UEL **2
528,0000
                CITED - SOVEL
529,0000
                PCT Y=CH*PHYN
530.0000
                IF (485(4(1+1)) +GF+ +5) 60 TO 101
531,0000
                MPTTE (11+103) 1+A(1+1)+VEF+H1+T(3+1+I)
532.0000
               FURMAT (14-4F12-4)
533,0000
                WRITE (13-104) A(2-1)-SRVEL-V1-1(3-2-1)
534.0000
                FORMAT (4%-4F12.4)
535.0000
                WELTE (11-105) A(3-1)-CH-H1-1(3-3-1)
536,0000
          10%
                FORMAT (4X-4F12.47)
537,0000
                CONTINUE
5 18,0000
                TINIT=11M
539,0000
                MPTTE (11+926)
540,0000
            924 LORMAL (77+* LIRESSURES AT THE MULL POINTS*)
                MRELL (11,927) (P(1)+1=1+121)
541,0000
542,0000
            927 FORMAT (10(2X)F10,2))
543,0000
                STOP
544.0000
                END
545,0000
                SURROUTTNE SETTEL (A-B-X-N)
546.0000 C
547,0000 C
                LIFRALIVE SOLUTION OF A SET OF SEMULTANEOUS
                LINEAR FORMS FORMS THE GAUSS-SEPEL METHOD
548.0000 C
549.0000 C
                DIMENSION A(N+N)+R(N)+X(N)+RMAT(175+175)+C(175)+X0LD(175)
550,0000
```

```
551,0000
               100 10 1=1.N
557,0000
               Y(T)=0.
553,0000 10
               CONTINUE
154,0000
                (()) =1 .E-4
               WRITE (11,15)
<u>ካትት፣ ሮሮ</u>ሮብ
556,0000 15
               FORMAT ( /* VALUES OF 1ST AND LAST X-ELEMENTS O*)
557,0000
                Ny tat or ou
558,0000
                ## (APS(ACT+T)).LT.1.E-30) 60 TO 40
559,0000
                IH) 20 J=1,N
560,0000
                RMAT(1.1)=-A(1.J)/A(1.1)
                IF CL.EU.J) BMAT(1,J)=0.
561,0000
542,0000-20
               CONTINUE
               ECD4RODZACI+D
563,0000
544,0000 30
                CONTINUE
565,0000
                60 TO 55
566,0000 40
                WPTH (11,50) I
                FORMAT (*0*, *DIAGONAL COFFFICIENT NO.*, 13, * =0.*)
ፕለፖ, የለቦር ፕቦ
568,0000
56,0000 55
                u0 110 M=1,500
570,0000
                NO 90 I=1.N
                XNLH(I)=X(I)
571,0000
572,0000
                SUM1=0.
                           573.0000
                SUM2=0.
574.0000
                IF (1.F0.1) GO TO 70
575,0000
                11=1-1
                nn 60 .l≈1•11 '' '
576.0000
577,0000
                SUNTASUMTEMAT(), J) *X(J)
                CONTINUE.
578,0000 60
579,0000 70
                17=1+1
580.0000
                1F (12.6T.N) GO TO 85
581.0000
                no 80 .1≈12•N
582.0000 "
                (L)XX(L+I)TAMATSMUR=SMUR
583,0000 80
                CONTINUE
584,0000 85
                X(I)=SUM1+SUM2+C(I)
585,0000 90
                CONTINUE
                WRITE (11795) X(1)7X(N)
584,0000
                FURMAT (2F12+5)
587,0000 95
508.0000
                RHAX≃O.
                tur 100 3=1.N
589,0000
                K=X(I)-YUL FI(I)
590,0000
                15 (R.IT.TH) GO TO 100
591,0000
                RRELANG(RZXCE)
592,0000
                RMAX=AMAX1 (RMAX+RREL)
593,0000
594,0000 100
                CONT TAUL
                H (RMAX.LT.TOL) GO TO 130
595,0000
594,0000 110
                COMETNO
597.0000
                WRITE (11-120)
                LORMAL (*0***THE NOT CONVERGE IN 500 TERRATIONS*)
598,0000 120
                SIOP
549,0000
600,0000 130
                RETURN
601.0000
                END
```

and the second second of the second s

では、現場のでは、日本の

## Sample of Input Data

0.,0.,297.,-138.,0.,0.,0.,

のようなできる。

## Sample of Output Data

1.0000											
2,0000	- TEM .	Abx	YBY	V9:		YI	71	-		• .	
3.00no	0.0000	0.0000	297,0000	-1.38.0000	0.0000	0.0000	0.0000				
4.0000							_				
5.0000 A.0000	THE FA , 4.34 S	4.0000									
7.0000	, 4.50 1	4.0000									
.8.0000	- 28	84.	VR			-					•
P.0000	4.1184	8.7340	327.4950								
10.0000											
11.0000	4.1104	8.2348	377,4950	-							
12.0000											
13.0000											
14.0000	K-COORTS. OF	MULL PO									
15.0000	4.87		1.40	2.45	1,95		.00	97	-1.95	-2.92	-3.90 -2.92
16.0000	-4.87 -3.90		1.87 1.87	3.90 4.87	3,90	1.95	1,95	.00	- 97 .00	1.75	-1.95
18.0000	-2.92		1.70	-4.87	4.87	3.90	2, 93	1.45	.97	100	-,97
19,0000	-1.94		.93	-3.40	-4.07	4.87	3,90	2.92	1.9%	.97	.00
20.0000	,97		.05	-2.92	-3,90	-4.87	4.07	3.40	2,93	1.75	.97
21.0000	.00		97	-1.95	-2.92	-3.90	-4.07	4.87	4. 40	2.72	1.95
22.0000	.97		.00	97	-1.95	-7.92	-3.90	-4.47	4.117	3.90	2,92
23.0000	1.95	-	.97	.00	,97	-1.95	-2.92	-3.40	-4.137	4.87	3.40
24.0000	2.42		.95	.97	.00	97	-1.95	-5.85	-3.40	-4.02	4.07
25.0000	7.90		.92	1.95	.97	.00	97	-1.9%	-3.92	-3.90	-4.87
24.0000	4.87	3	. 40	2.92	1.75	.97	.00	97	-1.95	-2.92	-3.90
27.0000	-4.87										
28,0000						· · ·					
30.0000	Y-COORDS. OF	MILL PO	INTE	-	•	-					
31.0000	-3,90		1.40	-3,90	-3,90	-3.90	-3.90	-3.40	-3.90	-3.70	-3.90
32.0000	-3.90		. 72	-2.92	-2.92	-2.92	-2.93	-2.92	-5.95	-2.92	-2.92
33.6000	-2,92		92	-1.95	-1,95	-1.95	-1.95	-1.95	-1,95	-1.95	-1.9%
34.0000	-1.93		. 45	-1.95	-,97	97	97	97	-,47	47	47
35.0000	, 47			97	97	00	00	00	00	00	00
36.0000	00	•	.00	00	~.00	00	.97	(4)	.97	.47	,47
37,0000	.77		.47	.47	.47	.47	.97	1.45	1.45	1.75	1.44
38.0000	1,95	1	.95	1.95	1.95	1,95	1.45	1.95	2.92	2.92	2.92
39.0000	7,92		. 47	5.45	2.92	2.92	5.45	2.92	5.45	3.90	1.90
40.0000	3,40		1.90	3.90	1.90	3.90	3.90	3.90 4.87	3.90	3.90 4.87	4.87 4.87
41.0000	4,87		1.87 5.85	4.87 5.85	4.87 5.85	5.85	5.85	5.85	5.85	5.65	5.85
43,0000	5.85 5.65	-	, 63	3163	2.444	3445	3.63	3.004	3169	3.6.	3.63
44,0000	,,,,,,										
45.0000											
46.0000	Z-COOKING, OF	MON L PT	PINIS								
47.0000	0.00		0,00	0.00	0.00 .	********	0.00	0.00	0.00	0.00	0.00
48.0000	0.00	•	0,00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47.0000	0.00	4	1,00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.0000	0.00		,00	·· 0.00 ·	0.00 -	0.00	0.00	0.00	0.00	0.00	0.00
51.0000	0.00		0.00	0.00	0,00	0,00	0.00	0.00	0.00	0.00	0.00
52.0000			0.00	0.00	0.00	0,00	0.00	0.00	0.00	0.00	0.00
53.0000	0.00		.00	0.00	0.00	0,00	0.00	0.00	0.00	0.00	0.00
54.0000	0.00		0.00	0.00	0.00	0,00		0,00	0.00	0.00	0.00
35.0000	0.00		n. 00	0.00	. 0,00	0,00		0.00	0.00	0.00	0.00
57.0000	00.00 00.00		0.00 0.00	0.00	0,00	0.00		0.00 0.00	0.00	0.00 0.00	9.00 9.00
38.0000	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00
59.0000	0.00	•	****	0.00	0.00	0.00	0.00	0.00	0.00	4.00	9.00
	O JOELEMENT N	nunius ic									
61.0000	41-22-41-44		PTMATES IN	THE POIN	TS FURNING	THE FLUTHING	19				
42.0000	71.72.71.74										
63.0000	71.77.1.73.74				IS FIRMING						
64.0000	LUIS FULL FULL	-COHEUM	INTS M' TH	F LIMIT MA	PHAL VECTOR						
45.0000	XPMP . YPNP . A	PANN-#COIN	KOLNATES ()	HM 3HT	L POINT IN	REFFIRENCE	CookHinate Sys	TEM			
66.0000											
67.0000			• • • •						•	-	
68.0000	J 41	, ,		3 x		KP58					
67.0000	Y1		Y? Y	3 <u>Y</u>		YFNP					
70.0000	21		12 X	3 <i>7</i>	4 UNZ	ZPNP	•••				
71.0000 72.0000	1 4.5		4.39	4.39	4.87	0.00					
73.0000							4.A3 4.90				
74.0000	0.0			0.00	0.00		0.00				
73.0000	***										

								the state of the s
76.0000	2	4.39	7.41	3.41	4,39	0.00	3.90	
77.0000		-4.39	-4.19	-1,41	-3.41	9.00	-3.40	
78.0000		0.00	0.00	0.00	0,00	1.00	0.00	the second secon
74.0000	_		* 2.44	2.44	3.41	0,00	7.92	
86.4460	3	3.41			-3.41	0,00	-3.90	
65'0060 61'0012		~4.39	-4.19 0.00	-3.41 0.00	0.00	1.00	0.00	
63.0000		0.00	0.00	0.00	V.00	1.00	0.00	
£4.0000	4	2.44	1.44	1.46	2.44	0.00	1.95	
85,0000	-	-4.39	-4.39	-3,41	-3.41	0.00	-3.90	· · · · · · · · · · · · · · · · · · ·
84.0000		0.00	0.00	0.00	0.00	1.00	0.00	
87,0000		••••						
0000.999	. 2	1.46	149	, 49	1.44	0.00	.97	
89,0000	•-	-4.39	-4.39	-3.41	-3,41	0.00	-3.70	
90.0000		0.00	0.00	0.00	0.00	1.00	0.00	
P1 .0000				•		•		•
92.0000	6	.47	-,44	-, 49	.49	0.00	.00	
93.0000		-4	-4.19	-3.41	-3.41	0,00	-3.40	the same of the sa
74,0000	• •	0.00	0.00	0.00	0.00	1.00	0.00	
95.0000			_					
ቀፋ "ጥነንን	7	49	-1.46	-1.46	49	0.00	97 -3.90	
<b>97.0000</b>	•	-4.30	-4.39	-3.41	-3.41	0.00 1.00		
<b>98.0770</b>		0.00	0.00	0.00	0.00	1.00	<b>9.00</b>	
49.00mg			2.44 -	2.44	5:46	- 0:00	*** -1 .95**	and the second section of the second section is a second section of the second section of the second section is a second section of the second section
100.0000								
101.0000		-4.39	-4.39	-3.41	-3.41	0.00	-3,90	
103.0000		0.00	. 0.00	0.00	0.00	1.00	0.00	
104.040	9	-2.44	-3.41	-3.41	-2.44	0.00	-2,92	
105.0000	* <b>.</b> .	-4,39	-4.39	-3.41	-3.41	0.00	-1,90	• •
204.0440		0.00	0.00	0.00	0.00	1.00	0.00	
107.0000		*****		••-•	••••	•		
108.0000	10	-3.41	-4.39	-4.39	-3.41	0.00	-3,90	•
109.0000	•••	-4.39	-4.39	~3.41	-3,41	0.00	-3.70	
110.0000		0.00	0.00	0.00	0.00	1.00	0.00	
111.0000				• -	•	•		
112,0000	11	-4.39	-5.34	-5.34	-4.39	0.00	-4,87	
113.0000		-4,79	-4.39	-3.41	-3.41	0.00	-3.90	
114.0000	···•	0'00	0.40	0.00	0.00	1.00	0.00	
115.0000								
116.0000	12	4,87	4.39	4.39	4.87	0.00	4.63	
117.0000	• •	-7.41	-7.49	-2144	-7.44	0.00	-5.65	
118.0000		0.00	0.00	0.00	0.00	1.00	0.00	
119.0000				3.41	- 4,39 -	. 0.00	3,90	and a second of the second of
120.0000	_12	4.39	-3.41	-7.44	-2.44	0.00	-2.92	
		-3.41	0.00	0.00	0.00	1.00	0.00	
122,0000		0.00	. 0.00	0.00	0.00	- ''''		and the second of the second o
174.0HID	14	3.41	2.44	2.44	3.41	0.00	2.92	
125.0000		-3.41	-3,41	-2.44	-2.44	0.00	-2.92	
126.0000		0.00	0.00	0.00	0.00	1.00	0.00	· · · · · · · · · · · · · · · · · · ·
127.0000			****					
128.0000	15	2.44	1.46	1 - 46	2.44	0.00	1.95	
129.0000		-3.41	-3.41	-2.44	~?.44	0.00	-2,92	· · · · · · · · · · · · · · · · · · ·
124.0000 170.0000		-3.41 0.00			0.00		0,00 -5,45	
131.0000 131.0000		0.00	0,00	-2.44 0.00	0.00	1.00	0.00	
131.0000 131.0000 132.0000	16	0.00 1.46	-3.41 0.00	-2.44 0.00	-7.44 0.00 1.44	0.00	0,00 0,00	
131.0000 132.0000 133.0000	14	0.00 1.46 -3.41	-3.41 0.00 49 · ·	-2.44 0.00 49 ·	-2.44 0.00 1.44 -2.44	0.00 1.00 0.00	-2.45 5.45	
131.0000 132.0000 132.0000 134.0000	···16 -	0.00 1.46	-3.41 0.00 49 -3.41 0.00	-2.44 0.00 49 · -2.44 0.00	-7.44 0.00 1.44	0.00	0,00 0,00	
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					45	0.00	.00			
180,000	24	. 49	49 -2.44	-, 49 -1 . 46	.49 -1.46	0.00	-1.95			
181.0000 182.0000		-2.44 0.00	0.00	0.00	0.00	1.00	0.00			
183.0000		0.00	411.4	****	••					
184.0000	24	-,47	-1.46	-1.46	49	0.00	-,47			
185,0000		-2,44	-2.44	-1.44	-1 - 44	0.00	-1.95			
184.0000		0.00	0.00	0.00	0.00	1.00	0.00			
187,0000	30	-1.46	-2.44	-2.44	-1.46	0.00	-1.75			
187.0000	•	-2,44	-2.44	-1.46	-1.46	0.00	-1.95			
170.0000		0.00	0.00	0.00	0.00	1.00	0.00			
. 141 '0000	• • • • • • • • • • • • • • • • • • • •			·						•
197.0000	31	-2.44	-3.41	-7.41	-2.44 -1.46	0.00	-2.92 -1.95			
194,0000		-7.44 0.00	-7.44 0.00	0.00	0.40	1.00	0.00			
195,0000		0.00	0.00	0.00	0.40	****	4.00			
194.0000	32	-3.41	-4.39	-4.19	-3.41	6.00	-3.90			
177,0000		-7.44	~~,44	-1.44	-1.46	0.00	-1.95			
198.00HQ		0.00	0.00	0.00	0.00	1.00	0.00			
199.0000		A 70		-5.34	-4.39	- 0.00	-4.07			
200.0000	33		-5.36 ·	-1.46	-1.46	0.00	-1.07			
201.0000 202.0000		0.00	0.00	0.00	0.00	1.00	0.00		-	
203.0000		0,00	0.00		****	• • • • • • • • • • • • • • • • • • • •				
704.0000	34	4.87	4. 19	4.39	4.87	0.00	4,63			
705,0000		1.46	-1.46	49	49	0.00	• 97			
204.0000		0.00	0.00	0.00	0.00	1.00	0.00			
207.0400 208.0000	35	4.39	3.41	3.41	4.39	0.00	3.40			
207.0000	33	-1.44	-1.46	~.49	-,49	0.00	97			
210.0000		0.00	0.00	0.00	0.00	1.00	0.00			
211,0000								• -	· · · - ·	
212.0000	36	3.41	2.44	2.44	3.41	0.00	7.92			
213.0000		-1.46	-1.46 0.00	, 49 0 , 60	49 0.00	0.00	0.00		•	
214,0000 215,0000		0.00	0.00	0.00	0.00	1.00	0,00			
216.0000	37	2.44	1.46	1.45	2.44	0.60	1.95			
217.0000		-1.46	-1.46	-, 49	49	0.00	-,97	-	-	
218.0000		0.00	0.00	9.00	0.00	1.00	0.00			
214.0000										
270.000	30	1 - 46	. 49	. 49	1.46	0.00	,97 -,97			
221.0000 232.0000		-1.46 0.00	-1,4A 0.00	0.00	0.00	1.00	0.00			
223.0000		•	0.00	0.00			****	•••	•	•• • • • •
2,4.0000	.319	. 49	44	49	. 49	0.00	.00			
225,0000		-1.46	-1.44	-,49	- , 49	0.00	97	•		
227.0000		0.00	0.00	0.00	0.00	1.00	0.00			
558*0000	40	40	-1.40	-1.44	49	0.00	97			
227.0000		-1.46	-1,44	- , 49	0	0.00	97			
2,00,0000		0.00	0.00	0,40	9.00	1.00	0.00			
241.0000										
237.0000	41	-1.44	-2.44	-2.44	-1.46	0.00	-1.95 47			
233,0000		~1.44 0.00	-1.46 u.00	0.00	-,49 0.00	1.00	0.00			
234,0000		-	4.00	0.00	0100		0.00		-	
0000.455	4.3	-2144	-4.41	- 3.41	-7.44	0.00	-2.92			
237,0000		-1.44	-1.44	49	44	0.00	-,0,			_
238.0000		0.00	0.00	0.00	0.00	1.00	0.00			
239,0000 240,0000	43	-3.41	-4. 19	-4.39	-3.41	0.00	~3.90			
241.0000	43	-1.46	-1.44	44	4.9	0.00	-,97			
242,0000		0.00	0.00	0.00	0.00	1.00	0.00			
243,0000										
244,0000	44	-4.19	5.36	-5.34	-4.30	0.00	-4,67			
245.0000 244.0000		-1.4A 0.00	0.00	49 0.00	0.00	1.00	47 0.00			
747,0000		0.00	0.00	0.00	. 0.00	1100	0.00			
248,0004	45.	4.87	4.19	4. 10	4.87	0.00	4.63			
747.141100		-,44	. 44	. 47	.49	0.00	00			
250.0000		6.00	0.00	0.00	0.50	1.00	0.00			· -
251.0000										
,751,0000, 0000,525	46	4,30	3.41	3.41	4.59	0.00	3.40		•	
251.0000	40	49	49	.49	. 49	0.00	00			
254,0000		9.00	0.00	0.00	0.00	1.00	A.46			
755.0000			-			0.00	2.42			
257, 0000	47	3,41 -,49	2,44	7.44	3,41	0.00	-,00			
257,0000		0.00	0.00	0.00	0.00	1.00	0.00			
754.0000										
260.0000	48	2.44	1.46	1.46	2.44	0.00	1.95			
241.00.00		49	49	.49	.49	0.30	00			
242.0000		0.90	0.00	0.03	0.00	1.00	0.00			
24.1.0000 244.0000	49	- 1.46	. 49	. 49	1.46	. 3.00	.47			
245,0000		49	-, 49	.49	, 49	0.00	co			
744.0000		0.00	0.00	0.00	0.00	1.00	0.00			
767,0000										
Deich, RAC		.49	44	49	. 49 . 49	0.00	.00 (40, -			
789,0000		0.00	0.00	0.00	0,00	1.00	3.03			• •
271.0-00		******	10.000	4,	2100					
222.0000		47	-1.46	-1,46	-,49	0.00	. , 97			
773-0000	)	-,49	49	. 49	. 40	0.00	40			
274.000		0.00	0.10	0.40	0.00	1	0,00			
275.0000		_ • • •	-7.48	-7,44	-1.44	0.00	.1.95			-
77A.0000		-1.44 47	49	.49	44	0.00	- , 176)			
278.0000		0.00	0.00	0.00	0.00	:.00	0.00			
779.0000	•					2.3				• •
		-2,44	-4,41	- 1.41	-7.44	0.00	-2.45			
280.0000										
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图集的数据设备的,这个人,这个人的人,这个人的人,是是一个人,是是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,他们

797.0000	54	-3.41	-4. 14	-4.37	-1.41	0.00	-3.90	
		-,47	49	44	. 49	0.00	00	A street of the transfer which there is no contract the street of the st
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2000, 685	* 55	-4.10	-5.34	-5.36	4,39			
284.0000		49	~,49	-71.30	-4,34	0.00	-4,A7	
29c) . 60mp		9.00	0.00	0.00	0.00	1.00	0.00	
241.0000				•				
29.1,0000 29.1,0000	54	4.97	4.39	4. 17	4.87	0.00	4.63	
274,0000	•	0.00	0.00	1.44	1.44	0,00	.97	
295.0000		0.00	0.00	0.00	9.00	1.00	0.00	* · · · · · · · · · · · · · · · · · · ·
294.0000	57	4.39	3.41	1,41	4,39	0.00	3.70	
797.0000		.49	49	-1.46	1.46	0,00		
24A,6000		9.40	0.00	0,00	9.00	1.00	0.00	•
297.0000	58	3.41	2.44 -					
301.0000	-			7,44	3:41	0.00	2. <b>9</b> 7	
30.2 .0000	-	0.00	.40	1.44	1.44	0.00	.97	
2000, 7.07.		01017	. 0.00	0.00	6.00	1,00	0.00	A R. COMMITTER TO SERVICE AND A R. COMMITTER TO SERVICE AND ADDRESS OF THE SERVI
304,0000	59	2.44	1.46	1.40	2.44	0,00	1.45	
305.0000		49	47	1.44	1.46	0.00		9 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
307,0000 cono.70E		0.40	0.00	0.00	0.00	1.00	9.00	
300,6040	60	*** 1.46	49					
304.0000		.49	. 49	1.44	1.46	0.00	. 97 . 97	
310.0000		0.00	0.00	0,00	9.00	1.00	0.00	
311,0000		••	•	• •	• •		- ~ ****	where we are the contract to the contract of t
317,abna 313,0440	٨١	.49 .49	•.40	-,44	.44	0.46	.00	
314.0000		0.00	0.00	0.00	1.44	0.00	,97	
315,0000		0.00	V.00	0.00	0.00	1.00	0.00	*
314,0000	62	49	-1.46	-1.46	~.49	0.00	-,97	
317,0000	••••	. 49	49 .	1.44	1.44	0.00		
310.0000		0.00	9.00	0.00	0.00	1.00	0.00	
317,0000	43	1.46	45,44 "	-7.44				
321,0000	0.1	.44	-49	1.46	*1.46	0.00	-1.95 .97	A STATE OF THE STA
322,0000		0.03	0.00	0.00	0.00	1.00	0.00	
323,0000					-		-	miles the terms of the control of th
374.00×0 375.0×00	64	-2.44	.1.41	-3.41	-2.44	0.00	-2,42	
324,0000		. 49 0.00	0.00 04.	1.44	1.44	0.00	.97	
327,0000		0.00	0.00	0.00	0.00	1.00	. 0100	* ****
320.0000	65	-3.41	-419	-4.39	-3.41	0.00	-3.90	
0000, 45E		149	. 49	1.46	1.46	0.00	.97	And the second of the second o
371,0000		0.00	0.00	9.00	0.00	1.00	0.00	
332,0000	. 66	-4,39	-5.34	5,36	-4.39			
335,0000		.49	.49	1.46	1.46	0.00	-4,87 ,97	The state of the s
334.0010		0.00	0.00	0.00	0.00	1.00	0.00	
3 44,0000			•					The state of the s
0000, AF E	47	4,87 1,48	4.39 1.46	4, 49	4.87	0.40	4.43	
338,000		0.00	0.00	., 44 0,00	0.00	1.00	0.00	
3 19. (Ми)					4.00	,,,,,,	G. GU	
140.0up0	ė R	4.39	3.41	7.41	4.39	0,44	3.40	
341.0008	<b>6</b> 8 .	1.44	1.44	2.44	4.39	0.00	3.46 1.95	- · · · · · · · · · · · · · · · · · · ·
341.000B 347.040	<b>△R</b> .				4.39 7.44 0.00		1.95	- · · · · · · · · · · · · · · · · · · ·
341.0008	. 69	0.00	1.4A 0.00	0.00	7.44 0.00	0.00 1.00	0.00	
341.0000 342.0000 343.0000 344.0000 344.0000	-	1.46 0.00 3.41 1.46	1.4A 0.00 2.44 1.4A	2.44	7.44 0.00 3.41	0.00 0.00	1.95 0.00 7.92	
341.0000 343.0000 344.0000 344.0000 346.0000	80 .	1.44 0.00 3.41	1.4A 0.00 2.44	7.44 0.00 7.44	7.44 0.00	0.00 1.00	0.00	
341,0000 \$42,0000 343,4000 344,3054 345,0000 346,0000 347,0000	. 49 .	1.44 0.00 3.41 1.44 0.00	1,4A 0,00 2,44 1,4A 0,00	7.44 0.00 7.44 7.44 0.00	7,44 0,00 3,41 2,44 0,00	0.00 1.00 0.00 1.00	1.95 0.00 7.97 1.95 0.00	
341,0000 343,4000 343,4000 344,5000 345,0000 347,0006 347,0006	80 .	1.44 0.00 3.41 1.46 0.00	1.4A 0.00 2.44 1.4A 0.00	7.44 0.00 7.44 7.44 0.00	7.44 0.00 3.41 2.44 0.00	0.00 1.00 0.00 1.00	1.95 0.00 7.92 1.95 0.00	
341,0000 \$42,0000 343,4000 344,3054 345,0000 346,0000 347,0000	. 49 .	1.44 0.00 3.41 1.44 0.00	1.4A 0.00 2.44 1.4A 0.00	7.44 0.00 7.44 7.44 0.00	7,44 0,60 3,41 2,44 0,00 2,44 2,44	0.00 1.00 0.00 1.00	1.95 0.00 7.92 1.95 0.00	
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341,0000 342,000 344,000 344,000 347,000 347,000 347,000 350,000 351,000	. 49 .	1.46 0.00 3.41 1.46 0.00 2.44 1.46 0.00	1.4A 0.00 2.44 1.4A 0.00 1.4A 1.4A	7.44 0.00 7.44 0.00 1.46 0.00	7.44 0.00 3.41 2.44 0.00 7.44 2.44 0.00	0.00 1.00 0.00 1.00 0.00 0.00	1.95 0.00 7.97 1.95 0.00 1.95 0.00	
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TRUE, COSCO	R0	3.41	2.44	2.44	3.41	0.00	7.07			·
\$40.0000		2,44 0,00	0.00	4.41	4.41	1.00	\$.V.			
391,00000		4,00		*****						
897, 16614	#1	2.44	1 - 46	1.46	7,44	0.190	1.5%			
MH10.1 VI		71.44	1.44	1.41	1.41	u.m	,,,,			
394.0000 394.0000		0.00	0.00	0,03	0.00	1.00	0,00			
TVA. OPOO	A?	1.45	. 49	. 47	1.44	0.00	.47			
397.0000		7.44	2.44	3.41	3,41	0.00	2.92			
(HMO, RP).		0.00	0.40	0.00	0.00	1.00	0.00			
399,0000 400:0000	63	. 47	47	47	.47	0.00				
401.0000	•,	2.44	2.44	4.41	3.71	0.00	2.92			
402.0000		0.00	0.00	0.00	0.30	1.00	0.00			
461.0000										
404.0000	<b>R4</b>	49	-1 - 44	- t . 46	- , 49	0.00	93			
405.00110 404.01110		0.00	2.44 0.40	1.41	1.41 0.00	0.00 1.00	0.00			
407.0000					****	••••				
408,0000	65	-1 . 46	-7.44	-7.44	-1 -46	0.00	-1.45			
409.0000 410.0000		2.44	2.44	1.41	1.41 0.00	1.00	9.00			
411.0000		0.00	0110	0.00	0,00	1110	9,00			
412.0440	86	-2.44	-1.41	3.41	>, 44	0.00	-3.93			
413.0000		. 44	2.44	3.41	1.41	0.00	2,42			
414,0000		0.00	0.00	0,00	0,00	1.00	0.00			
414.0000	817	.3.41	-4.39	-4.99	-3.41	0.00	3.90			
417,0000	•••	2,44	2.44	3,41	1.41	0.00	רט,יי			
416.0500		0.00	0.00	0.00	0,00	1.44	0.441			
419.0000				5.34	-4.30	0.00	-4.87		·	
470.0000 471.0000	88	-4	-5. \A	3.41	3.41	0.00	2.4.1			
472,0000		0.00	0.00	04.0	0.00	1.00	0,00			
423,0000										
424,0000 425,0000	94	4,87 3.41	4, 17 3.41	4, 17	4, 19	0.00	4,61			
474.0000		0.00	0.00	0,00	0.00	1.00	0.00			
427.0000										
428.0000	40	4.39	3.41	1.41	4. 19	0.00	8,00			
479,0000		3.41	3.41	4.14	4, 19 0, 00	(H) (Q)	0,46 00,6			
431,0000		0.00		0.00	••••	•••				
417.0000	<b>*1</b>	3.41	7.44	21.44	3.41	0.00	2.9.			
431,0000		4.41	3.41	4,47	4.14	a) , e)e) ( , e)e)	0.40			
4.19, (1970)		01,00	0.00	17.00	0.00	1.444	17.00			
4 60.14740	**	2.44	1.46	1,40	*, 44	છે, હોલો	1.5%			
4 (1, 1444)		3.41	4.41	4, 10	4. 10	s) , shi	.1,70			
4 10 . 00 mg 4,14 . (e) mg		0.00	0.16	O, OH	0.00	1.44)	0.00			
440,1444	71	1.46	. 49	. 49	1.46	4,40	.47			
441.444.45	-	3.41	3.41	417	4, tv	ou, o	1,-41		· -	
44.1,19919		0.00	0 - 143	0.00	0.00	1.40	c) , e(t)			
441,0000	74	.49	49	.49	. 49	0.00	.00			-
445,0000	• •	1,41	1,41	4. 19	4. (v	0.00	1,90			
444.0000		0.00	0.00	0.00	0.40	1.00	6.00			
44), (HHW) 44H, Whit	45	49	-1.46	-1.44	49	d, thi				
447,0000	•.•	1,41	1,41	4. 19	4.39	0.00	4.50			
450.0000		0.00	0.00	0.00	0.30	1.00	0.00			
451.0000			_						<b>.</b> •	
452,0000 453,0000	. 44	J. 41	-7.04 3.41	-:*. 44 4. 37	-1.4n 4.3v	() , ()() () , ()()	1,45			
454.0000		0.00	0.00	0.00	0.00	1.00	0,10			
455.0000			•	•					• • •	•
45A, chhui	9,	-2.44	-1.41	-3.41	'.44 4.19	0.141	1, 40			
457,0000		0.00	0.00	4.10	0.00	0.00 1.00	0.00			
454.0000		0.00	0.00	4.101		••••				
440.0000	98	- 1. 41	-4.37	4. (4	4.41	0.00	-1.90		<b>-</b>	
4A1,00000		1.41	1.41	4.79	4, 19 0,00	(h. 14)	09.1			
463.0000		0.00	0.00	(0,000	0,00	4 4 1 3 1				
444.0000	44	-4.39	-5, ta	·5, ts	-4, (4	0,00	-4.87			•
444.0000		1.41	3.41	4.40	4, 10	0.00	1,40			
464.0000		0.00	9,00	0.40	0,00	1,40	6.60			
4A7, ሰብርብ 4AH, መዝንው	100	4,147	4, 17	4, 19	4.49	40. 191	4.48			
444.0000		4.19	4. 14	5. 14	** 6.4	0.00	4.117			
410.000		0.00	0.00	0.00	0.00	1.00	6.05			
471.0000		419	3.41	3.41	4.19	0.00	7 40			
473.0000	101	4.50	4, 19	9.76	5.14	0.00	4,87			
474,0000		0.00	40,00	40.440	0.40	1 , 1847	0.40			
475,0000										
426.00-00	102	3.41	2.44	2.44	3,41 5, to	13 ° 6,41	2,42 4,82			
477.0000		0.00	4, 19	5, IA 0.00	0.00	1.00	0.00			
479,0000					•			-		
489.00%	103	2.44	1.44	1.44	2.44	O. (h)	1.45			
401,0000		4.49	4. 14	۰.۱۸ ۵.۵۵	5. IA 0.00	0.00 1.00	4,47			
482,0000 483,0000		0.00	4.00	y, wi	4.00					
484.0000	104	1.46	.44	. 49	1.46	0.00	,0)			
445.0000		414	4,.59	2. 84	5.14	(1.1%)	4,87			
464,000m) 467,000m)		0.00	0,00	est, chr	4.40	1 . 134)	0.40			
488.6000	105	. 49	- , 49	-,49		0.00	Gro.	***		-
489,0000		4. 44	4. (4	7. W	5,.IA	0.00	4.117			
498.0000		0.00	0.00	0,00	de, de	1.00	63.000			

44. Other	100	-, 44	-1,48	-1.45	-,49	0,00	- 143			
49 L, Onno 494 , ODDO	_	0.00	4.19	۰. ده ۵.۵۵	4. 14	0.00	4.87			
495,0000		11100	0.00		(1.141	1.00	0.00		_	•
944,0000	10/	-1.46	44	-2.44	-1.46	0.00	-1.47			
440,0000 440,0000		0.00	4.34	5. IA	AA 60 , 60	0.00	4.617			
444,0000		0.00	4,00	13,00	0,40	1.00	0.00			
300,0000	fon .	7.44	-7.41	-3.41	2.44	0.00	-7.72			
901,0000 909,0000		4.3Y 9.08	4 , 3V 0 , 00	5.4A 0.00	5.36	0.00	4.017			
303,0000		4,110	0,141	0,00	0.00	1.00	0.00			·
<b>:44.</b> (MHH)	104	- 4.41	-4, 10		-1.41	ų, <u>00</u>	-,1,40			
ሰተሰብ . ለሱድ		4, tv	4. t9 0.co	A . W	5. 34	0.00	4.87	-	•	
507.0000		427041	41,441	4,64	dife, de	(10,00)	4,06			
308.0000	110	-4.39	-5.94	-5.34	-4,39	0,00	-4.87			
309,0000 319,0000		4. 19	4.19	54	5. W	0.00	4.87			
311.0000		0.00	0.00	0.00	0.00	1,00	0,00		<del></del>	
512,0000	111	4,87	4	4. 17	4,87	0.00	4,41			
513.0000 514,0000		5. W	7. M	4.73	٨٠.١١	0.14)	5.85			
815.0400		0.00	0.00	0.00	0.00	1.00	0.00			
314.0000	112	4. 10	3.41	3.41	419	4.00	4.90			
317,0000		7.74	7. 7.	4.31	٨. ١٦	0.00	4,45			• • • • •
\$19,0000		4) , 4(4)	4.00	() , nd	6,60	1.00	0,00			
<b>ዓ</b> ድል , ሰለነለ	113	7.41	7.44	2.44	3,41	0.00	7.97	-		•• ••
371,0000		5.36	5.34	4.33	۸, ۱۵	0.00	5.45			
522.0000		0.00	e , en	0.00	0.00	1.40	0.00			
5,74,0000	114	44	1.44	1.44	7.44	0.00	1,95			
\$25,0000		ها.٠٠٠	70 64	4.11	1,1 . 6	), (4)				
324,000A 327,0000		0.00	0.00	0.00	0.00	1.00	0,00		•	
324.0000	115	1.44	.49	. 44	1.46	0.00	.97			
254,0000		7.16	5.34	6.11	12.0	0,00	5.8%			A SEP WILLIAM CO.
5 W , OANO 5 S I , JJAN		0.40	a, ou	0,00	0,00	1.thi	0.10			
537.00.10	114	. 49	49	-,49	. 40	0.00	,00			-
\$31.0000		ካ ፡	5.46	A. 33	۸. ۱.۱	0.00	5.85			•
514.0000 515,0000		0.00	0.110	. 4.00	0.00	1.00	0.00	- <b></b>	<b></b>	
STA. DINIO	117	49	-1.44	-1.44	47	0.00	7/			
517,11440 6666,87 <i>8</i>		5. IA 0.40	5.14	A . 3.3	4.11	0,00	5.45			
4 80.00-20		0.40	0.00	0,00	0.00	1.00	0.00			- •
*.40.00.00	110	-1.44	-7.44	-:*.44	-1.46	0.00	-1.45			
541,0000		4, 14 00,0	5.84 0.00	A, 11 0.00	# A.4% 0.00	0.00	4, 194 () () ()			
548,0000				******	<b>0.11-1</b>					
244, nn:x1	117	-7,44	-3.41	-3.41	-7.44	0.00	-2,92			•••
345,4000		5.14	5.36	4,31	3.3	0.00	. 194			
344.0000					0.00	1.00				
344.0000	<b>.</b>	0.00	0,00	0,00	0.00	1.00	0.00			
347.0000 344.0000	120	-1.41	-4.34	-4, 19	-3.41	0,00	-4,40			
547.0000 544.0000 547.0000 530.0000	120	•		-	· • <del>-</del>		-3. Vo 5. A5			
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